DP-200

Electronic Calibration Lab
7000 Franklin Blvd., Suite 1220
Sacramento, CA. 95823
(916) 392-5404

HICKOK

LEADER IN DEPENDABILITY SINCE 1910

Electronic Calibration Lab
7000 Franklin Blvd., Suite 1220
Sacramento, CA. 95823
(916) 392-5404

INSTRUCTION MANUAL

for

DIGITAL MEASURING SYSTEM

CAPACITOR PLUG-IN model DP-200

© THE HICKOK ELECTRICAL INSTRUMENT CO. 1967

10514 DUPONT AVENUE • CLEVELAND, OHIO 44108

Printed in U.S.A.

HICKOK Precision Test Equipment

DMS-3200

DIGITAL MEASURING SYSTEM

(Fully transistorized)

DMS-3200 Main Frame —
(Shown with DP-100 PI)

MODEL DP 100 DC PLUG-IN
MODEL DP 150 1MC COUNTER
MODEL DP 170 RESISTANCE PLUG-IN
MODEL DP200 CAPACITOR PLUG-IN
MODEL DP 140 EVENT COUNTER

DP-100
DC Voltmeter
Plug-in

DP-150
1MC Counter
Plug-in

DP-170
Ohmmeter
Plug-in

DP-200
Capacity Meter
Plug-in

DP-140
Event Counter
Plug-in

Prices and Specifications subject to change without notice.

The Hickok DMS-3200 Digital Measuring System is a precision electronic measuring device which displays readings in digital form instead of the relatively inaccurate and difficult-to-read moving-pointer meter display.

Because the DMS-3200 consists of a main frame which will accept a number of "plug-in" units, it can be used to measure a variety of electrical parameters. The main frame provides display of the reading; the plug-in determines the application.

***Depending on the plug-in selected the instrument can be a:**

- Digital DC Voltmeter
- Digital AC Voltmeter
- Digital Counter
- Digital Frequency Meter
- Digital Ohmmeter
- Digital Capacity Meter
- Digital Current Meter
- Digital Multimeter
- Digital Ratio Meter
- Event Counter
- Digital display of time, stress, flow, temperature, etc.
- Linear Multiplier

The DMS-3200 is designed for rugged industrial and laboratory applications. Solid-state construction and conservative design ratings insure long, trouble-free life. By utilizing a design which has the optimum combination of accuracy capability and number of digit display, the DMS-3200 meets the general purpose measurement needs of industry for reliable digital measurement equipment in the $400 - $500 price range.

Additional Plug-In units will be announced periodically by Hickok. All Plug-In units are available through franchised Hickok Industrial Distributors.

THE HICKOK ELECTRICAL INSTRUMENT CO. • 10514 Dupont Avenue • Cleveland, Ohio 44108

DP-200 CAPACITOR
INSTALLED INTO
MODEL DMS-3200

DP-200

DIGITAL MEASURING SYSTEM

© THE HICKOK ELECTRICAL INSTRUMENT CO. 1967

10514 DUPONT AVENUE • CLEVELAND, OHIO 44108

PHONE — 541-8060
TWX — CV 662

CABLE — HICKOK, CLEVELAND
WESTERN UNION — KJ

2490-559

WARRANTY

The Hickok Electrical Instrument Company warrants instruments of its manufacture to be free from defects in material and workmanship for ninety (90) days from the date of original purchase. Any instrument found to be defective during this period may be returned, transportation prepaid, to the factory for repair, or at our option, replaced without charge.

This warranty does not apply to any of our products which have been repaired or altered by unauthorized persons, or which have been subject to misuse, negligence, or accident, or which have had the serial number altered, effaced or removed. Neither shall the warranty apply where a warranty registration card has not been properly completed and returned to us promptly after purchase. This warranty is in lieu of all other warranties whether expressed or implied.

RETURNING EQUIPMENT FOR REPAIR

Before returning any equipment for service, the factory must first be contacted, giving the nature of the trouble. Instructions will then be given for either correcting the trouble or returning the equipment. Upon authorization, this equipment should be forwarded directly either to the Hickok factory address at 10626 Leuer Avenue, Cleveland, Ohio, 44108, or to a designated service station in your locality.

TABLE OF CONTENTS

Section		Page
General Information		1
I	Specifications	1
II	Function of Front Panel Connectors	2
	Range Switch	2
	Display Control	2
	Picofarad Cancel Control	2
	Capacitor Input	2
III	Operating Instructions	3
	The Overrange Light	4
	Sources of Inaccuracy	4
	Series Resistance	4
	Spurious Voltage Effects	4
	Environment	5
	Line Voltage or Frequency Changes	5
IV	Circuit Description	5
	Simplified Block Diagram Circuit Operation	5
	The Complete Block Diagram Circuit Operation	6
	The Frequency Countdown	6
	The Unknown Capacitor Flip Flop	6
	The Switch Driver	6
	The Charge-Discharge Switching	6
	The Capacitor Source	6
	Capacitor Discharge Resistors	7
	Picofarad Cancel	7
	The Integration Network #1	7
	The Chopper	7
	The Amplifier	7
	The Demodulator	8
	The Integrator	8
	The Amp Inverter	8
	The Display Time Generator	8
	The Sync Gate	8
	The Display Flip Flop	8
	Neon Trigger Circuit	8
V	Service Procedure	8
	The Countdown Circuitry	11
	The Gating Circuitry	11
	The Capacitor Under Test Circuitry	11
	The DC to Frequency Converter	11
	The DC Difference Amplifier	11
	The Frequency to DC Converter	12
VI	Calibration Procedure	12
VII	Parts List	17

List of Tables

		Page
Table I	Shunt Leakage Allowable for 1% Error	4
Table II	Values of R	4
Table III	Maximum Series Resistance	4

List of Illustrations

Model DP-200 Capacitor Plug-In	1
Fig. 1. Simplified Block Diagram	6
Fig. 2. DP-200 Complete Block Diagram	7
Fig. 3. DP-200 Waveforms	9
Fig. 4. Servicing Etched Circuit Boards	10
Fig. 5. Component Locations - Unknown Capacitor Board	14
Fig. 6. Component Locations (Sheet 1 of 2) - Resistors Only	15
Fig. 6. Component Locations (Sheet 2 of 2) - Other Components	16
Schematic Wiring Diagram	Back of Manual

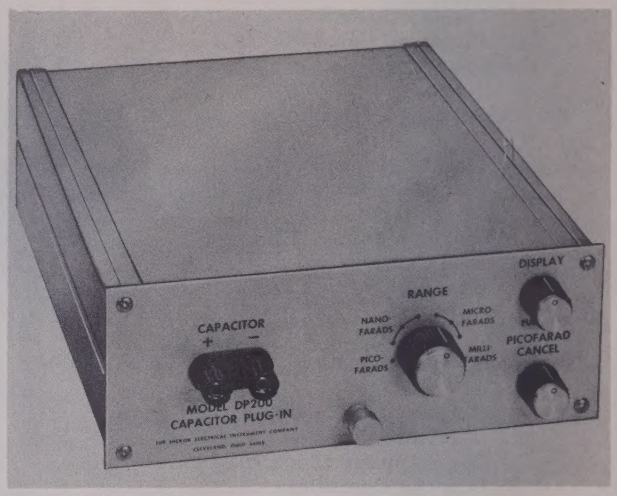
GENERAL INFORMATION

The Type DP-200 Capacitor Plug-in, when used with the DMS-3200 Main Frame, provides numerical display of capacitor values from 1 picofarad to 10,000 microfarads in eight ranges. This highly accurate instrument features an overrange capability of 40% and no required calibration for periods of a year or more. The accuracy specifications of 0.1% of reading ±0.1% of full scale for midranges includes the effect of ambient temperature changes, line voltage variations, and line frequencies from 47 to 400 cps.

The fast response speed of the instrument coupled with its packaging in a small rugged housing that slips into a DMS-3200 makes it ideal for production line testing, incoming inspection tests, or general laboratory use. The single polarity test signal negates the need for bias on polarized electrolytic capacitors. The low voltages used for testing the capacitor makes the instrument useful for testing any and all capacitors. The Picofarad Cancel enables the operator to cancel stray capacities on the low ranges thereby simplifying testing procedures.

The automatic decimal point location combined with simplified switch nomenclature reduces operator errors to a minimum. Personnel with no experience using an instrument of this type can obtain quick accurate measurements with very little training. No complicated setups are required, and no balancing is required. Simply plug the capacitor on the input terminals and the DMS-3200 displays the capacitor value numerically.

The DP-200 is intended for general use throughout the laboratory, for industrial and service applications, and for use anywhere capacitors are to be measured quickly, easily, and accurately.



Model DP-200 Capacitor Plug-in

SECTION I
SPECIFICATIONS

Specifications - DP-200 in DMS-3200 Main Frame

Capacitor Ranges:

000.	to	999.	picofarads
0.00	to	9.99	nanofarads
00.0	to	99.9	nanofarads
000.	to	999.	nanofarads
0.00	to	9.99	microfarads
00.0	to	99.9	microfarads
000.	to	999.	microfarads
0.00	to	9.99	millifarads

Linearity and accuracy is maintained for capacitor values up to 40% greater than full scale, except on the XXX. microfarad and X.XX millifarad range which have no overrange capability. An OVERRANGE light is provided.

Accuracy:

Temperature: 15°C to 35°C

Range	Indicated Reading
Millifarad	± 0.1% of full scale ± 0.9% of reading
All other ranges	± 0.1% of full scale ± 0.1% of reading

Temperature: 10°C to 45°C

Range	Indicated Reading
Millifarad	± 0.1% of full scale ± 1.1% of reading
All other ranges	± 0.1% of full scale ± 0.3% of reading

These accuracies hold for any type of capacitor having equivalent shunt leakage resistances at least 5 times the values listed under Allowable Shunt Leakage Resistance for 0.1% Additional Error. Under normal conditions even the lowest performance capacitors have specifications far in excess of those required to maintain the above stated accuracies.

Allowable Shunt Resistance for 0.1% of reading Additional Error:

Range	Shunt Resistance
XXX. picofarad	20 megohm
X.XX nanofarad	2 megohm
XX.X nanofarad	2 megohm
XXX. nanofarad	2 megohm
X.XX microfarad	200K ohm
XX.X microfarad	20K ohm
XXX. microfarad	2K ohm
X.XX millifarad	1K ohm

Long Term Stability - .05% per year

Drift and Offset: Negligible

Capacitor Test Signal:

Voltage is always positive on + terminal of input terminals. Shorting of terminals will cause no damage to the instrument.

Range	Voltage Impressed on Capacitor
Millifarad	+ 1 volt
all other ranges	+ 2 volts

Reading Time:

Approximately 200 msec.

Response Time:

Ranges	Response Time
XXX. picofarad X.XX nanofarad XX.X nanofarad	In response to a step of full scale, the unit will reach ± 0.1% of final reading within 1 second
XXX. nanofarad X.XX microfarad XX.X microfarad XXX. microfarad	In response to a step of full scale, the unit will reach ± 0.1% of final reading within 2 seconds.
X.XX millifarads	In response to a step of full scale, the unit will reach ± 0.1% of final reading within 10 seconds.

Display Time:

Continuously variable from approximately 1/2 second per reading to approximately 5 seconds per reading. Pulling out the Display time knob retains a reading indefinitely.

Environment:

Operating 10°C to 50°C with accuracies as stated in Accuracy specifications.

Mounting:

Plugs into DMS-3200. Secured by knurled knob.

Operating position - any

Size:

3" high x 8-1/4" wide x 10" deep

Weight:

3.5 pounds

SECTION II
FUNCTION OF FRONT PANEL CONNECTORS

Range Switch:

The range switch chooses the full scale range of the instrument. As the range switch is switched the decimal points of the reading are automatically located in the readout. If the range is insufficient for the capacitor to be measured the OVERRANGE light will be turned on.

Display Control:

The Display control determines the number of readings per minute the instrument will make. This is variable from about 2 readings per second to one reading each 5 seconds. This does not affect the time required to take the reading (approximately 200 msec). The knob of the Display control may be pulled out to hold any reading until the knob is again pushed in. If the instrument is in the process of taking a reading when the knob is pulled, the instrument will complete the reading and then hold it indefinitely.

Picofarad Cancel Control:

The picofarad cancel control is used to remove the effect of lead and test set up stray capacitance from the readings on the XXX. picofarad and X.XX nanofarad ranges. The control has effect only on these two ranges. The instrument is designed to have an offset of from 1 to 20 pF appearing at the input. This capacity, as well as any external stray capacity up to a minimum of 30 pF can be cancelled from the reading by use of the Picofarad Cancel control.

Capacitor Input:

The capacitor to be measured is placed on the input terminals. For polarized capacitors the polarity of the capacitor should match the + and - sign on the input terminals. i.e. + to + and - to -. When measuring low value capacitors the Picofarad Cancel control may be used to remove stray capacity from the reading.

SECTION III
OPERATING INSTRUCTIONS

CAUTION

A. The input of the instrument is not protected for large capacitors with voltage already impressed on them. Permanent damage may result if voltages in excess of 10 volts are on the capacitors when placed on the input terminals. NO DAMAGE WILL BE INCURRED BY OVERLOADING THE INPUT WITH A CAPACITOR TOO LARGE FOR THE RANGE OR BY SHORT CIRCUITING THE INPUT.

B. Refer to the specifications on the Model DMS-3200 to insure that the line voltage and frequency are within the ratings and that the line cord is properly connected to the power line.

C. Turn the DMS-3200 Main Frame OFF when inserting or removing plug-in units!

1. Insert the DP-200 Plug-In into the DMS-3200 Main Frame. To insert the plug-in into the main frame, line up the plastic slides located on the side of the plug-in with the slides in the access port of the main frame. The slides in the main frame are located about midway up the access port on either side of the main frame. Slide the plug-in into the main frame until the front panel of the plug-in is flush with the front panel of the main frame. Turn the aluminum locking shaft knob (center, bottom of plug-in front panel) clockwise until it is hand tight.

2. Turn on the instrument. The line switch is located on the front panel of the DMS-3200.

3. Allow 1 minute for normal operation to commence.

4. Note that no calibration is normally required with this instrument. For periodic maintenance schedule to maintain stated accuracy consult Section I, Specifications.

CAUTION: NEVER CONNECT A VOLTAGE SOURCE OF ANY TYPE TO THE INPUT TERMINALS OF THIS INSTRUMENT. Not only will it cause incorrect readings, but may also damage the instrument.

To Measure Capacitors:

1. Select a range expected to give a 3 digit reading for the capacitor to be measured.

2. Connect the capacitor to the input Capacitor terminals. If the capacitor is a polarized type capacitor observe the polarity signs, i.e. + capacitor terminal to + input terminal.

3. Press the Display time control and adjust until readings occur at a comfortable rate.

4. Allow sufficient time for the instrument to respond. The time required is listed in the specifications. The first reading following this time period will be correct.

5. If the reading does not use the full readout capability or if the OVERRANGE comes on, readjust the Range until a 3 digit reading is obtained and the OVERRANGE light is not on.

6. Read on the DMS-3200 Main Frame the numerical value including the decimal point. Suffix this numerical reading with the nomenclature for the selected range on the DP-200 front panel. This completes the reading.

For a low value capacitor (capacitor measured on the XXX. picofarad or X.XX nanofarad ranges).

1. Select the range expected to provide a 3 digit reading.

2. Connect all measurement leads or blocks to the input terminals. Do not connect the capacitor to be measured. When measuring low value capacitors to obtain accurate measurements care must be taken to assure that no error is introduced by the test setup. If the capacitor is not connected directly to the input terminals the connecting arrangement should be rigid and after adjusting the "Picofarad Cancel" the setup should not be tampered with. If adjustments are required the Picofarad Cancel should be checked and readjusted if necessary.

3. Press the Display time control and adjust until readings occur at a comfortable rate.

4. Adjust the Picofarad Cancel to a 000 reading or some other convenient reading, i.e. a reading of 010, OVERRANGE not lighted. DO NOT OVER CANCEL. Adjust the Picofarad Cancel just far enough to obtain a 000 reading and no farther. Overadjusting will cause the readings to be low.

5. Place the capacitor to be measured on the input terminals or leads.

6. Read value using same procedure as for any capacitor. If Picofarad Cancel was not set for a 000 reading, subtract the original reading from this measurement.

7. If the reading does not use the full readout capability or if the OVERRANGE comes on, readjust the Range if possible until a 3 digit reading is obtained and OVERRANGE light is not on.

The Overrange Light:

This indicator is lighted when the main frame counts past 999. This is the normal condition when the capacitor being measured exceeds the full scale value. The DP-200 is designed to allow up to 40% overrange without additional error. This means that on the XXX nanofarad range a 1.4 microfarad capacitor will read 400 and the OVERRANGE indicator will be lighted. The capacitor will read 1.40 on the X.XX microfarad range. This feature is particularly valuable when measuring capacitors of approximately full scale value because a capacitor of slightly larger value does not necessitate range changes.

Sources of Inaccuracy:

High-leakage-capacitor and in-circuit capacity measurements are possible with the DP-200 providing shunt resistance is sufficiently high. In normal measurements of capacitors the shunt leakage of even the lowest performance capacitor is many times smaller than allowable leakage specifications for stated maximum accuracy of the DP-200. A reduced accuracy reading can be made in quite low circuit impedances. The specifications list the minimum shunt resistances to maintain stated accuracy.

As an example of accuracy reduction by shunt leakage for 1% error the shunt leakages noted in Table I can be tolerated.

Table I

Shunt Leakage Allowable for 1% Error

Range	Shunt Leakage
XXX. picofarad	2 megohm
X.XX nanofarad	200K ohm
XX.X nanofarad	200K ohm
XXX. nanofarad	200K ohm
X.XX microfarad	20K ohm
XX.X microfarad	2K ohm
XXX. microfarad	200 ohm
X.XX millifarads	200 ohm

An approximate formula for determining the error caused by shunt leakage is:

$$\% \text{ inaccuracy} = 200 \left(1 - \frac{R_L}{R + R_L}\right)$$

R_L - is the shunt leakage resistance measured in ohms

R - values for R are listed in Table II.

The formula holds for values of shunt leakage resistance down to the values listed as Minumum Allowable R_L. For values of shunt leakage resistance below these values other effects cause rapid deterioration of accuracy in addition to the effects covered by the formula.

Table II

Values of R

Range	R	Minimum Allowable R_L
XXX. picofarad	10,000	20 ohm
X.XX nanofarad	1,000	20 ohm
XX.X nanofarad	1,000	20 ohm
XXX. nanofarad	1,000	20 ohm
X.XX microfarad	100	20 ohm
XX.X microfarad	10	40 ohm
XXX. microfarad	1	200 ohm
X.XX millifarad	.5	200 ohm

Series Resistance:

Series resistance in most normal capacity measurements is not a consideration. Even the lowest performance capacitors have series resistance many times lower than that which would affect readings with the DP-200. Series resistance has the immediate effect of reducing the overrange capability of the instrument. As the resistance becomes excessive it will reduce the maximum accurate reading on a given range. The accuracy will be maintained up to the limiting point and deteriorate rapidly above this point. A list of maximum series resistance to maintain the 40% overrange capability and a second value maintaining full scale accuracy is in Table III below.

Table III

Maximum Series Resistance

Range	Maximum series resistance for 40% overrange capability	Maximum series resistance for full scale capability
XXX. picofarads	1K ohm	2.5K ohm
X.XX nanofarad	100 ohm	250 ohm
XX.X nanofarad	100 ohm	250 ohm
XXX. nanofarad	100 ohm	250 ohm
X.XX microfarad	5 ohm	25 ohm
XX.X microfarad	.5 ohm	1 ohm
XXX. microfarad	---	.1 ohm
X.XX millifarads	---	.05 ohm

Spurious Voltage Effects:

The DP-200 uses reasonably high level voltages to avoid most possible errors. However, the actual measurement circuitry uses sensitivities of the order of 50 mv for a full scale reading. Voltage sources connected with the external circuitry can cause considerable error in measurements if not properly eliminated. Voltages in series with the unknown capacitor will not cause error if they are below 10 mv. This is not a critical region as most spurious voltaic and thermally generated voltages are below this level. However, voltages in parallel with the unknown capacitor will cause difficulties. A voltage

of 100 uvolts in parallel with the capacitor under test will cause 1 digit error.

Environment:

A number of possible sources of error are introduced by severe environments. The DP-200 is designed to eliminate as many of these as possible. Both temperature and humidity factors have been taken into account. The unit's specified accuracy under varying temperature conditions is in the Specification section of this book. Humidity effects have been reduced by extremely careful treatment of insulating surfaces. If errors are encountered which can only be attributed to environmental changes, these most likely will be found in the external measurement setup. Two precautions should be noted:

Corrosive atmospheres, particularly when the humidity is high, can cause large leakage currents. The DP-200 is totally enclosed, and should not be opened nor otherwise exposed to industrial atmospheres. The test setup, as well, should be kept as clean as possible. In the event of difficulties, clean, dry Freon TF mixed with Dow-Corning Silicone Oil DC-200 in a ratio of 50:1, should be used to carefully clean contaminated binding posts, switches or other leakage paths. (When cleaning the DP-200 remove the lucite rods in the chopper.)

Many electronic components will generate spurious voltages under high humidity conditions due to galvanic (battery) action. These voltages are most often in the microvolt range, but can sometimes cause strange and inexplicable errors. The DP-200 itself is free from these effects and so the trouble usually can be traced to the external circuitry under test.

Line Voltage or Frequency Changes:

No errors at all will be introduced by line voltage changes of from 105V rms to 125V rms, nor by frequency changes of from 47 cps to 400 cps, or any combination of the two.

SECTION IV
CIRCUIT DESCRIPTION

Simplified Block Diagram Circuit Operation:

The function of this plug-in is to convert a capacitor value to a burst of pulses wherein the number of pulses in the burst is precisely equal to the capacitor under test. (A change in the capacitor under test changes the number of pulses in the burst, but not the duration of the burst). The main frame counter will then count and display the total. Each burst is preceded by a reset pulse which assures that each count starts from zero. This reading, the displayed total, is retained for a period of time controlled by the display time generator. This display time is varied by a front panel control. Pulling the control knob disables the display time generator thus allowing the reading to be retained indefinitely.

The simplified block diagram explains the basic method of producing an accurately determined burst of pulses. The dc input voltage to the voltage measurement circuitry is Ec. Ef is a dc feedback voltage of the same polarity as Ec. The difference, Ec - Ef, is amplified, inverted, and fed to the input of the dc-to-frequency converter. This circuit generates a pulse train whose frequency is approximately proportional to voltage fed to it. This pulse is used to activate a highly precise frequency to dc converter. The output of the Feedback Frequency to DC Converter is Ef. Ef is proportional to the product of the standard voltage source and the frequency within about ± 0.01%. By making the gain of the dc difference amplifier very high, Ef will be very nearly equal to Ec and consequently, the frequency of the pulse train will be held proportional to Ec to within a few parts in ten thousand.

The production of voltage Ec to be proportional to the capacitor size is accomplished in the same manner as the frequency to dc conversion previously mentioned. The capacitor under test is inserted in a switching arrangement which charges the capacitor from the Standard Voltage Source. The charged capacitor is then disconnected from the voltage source and allowed to discharge through a resistor. The average voltage across the resistor then becomes Ec. Ec will be proportional to the capacitor value within about ± 0.02%. The ranges of capacitors measured are adjusted by adjusting either the frequency of the Unknown Capacitor to DC Converter or the resistor through which the capacitor under test discharges.

Because the Standard Voltage Source supplies the voltage both for the capacitor under test and the Feedback Frequency to DC Converter, if the voltage changes there will be no change in the difference Ec - Ef. With no change in Ec - Ef there will be no change in the output pulse train.

The frequency of operation of the Unknown Capacitor to DC Converter is determined by the Frequency Countdown. If this drifts, Ec will change and therefore the frequency of the output pulse train will drift. However, to obtain a reading on the DMS-3200 a pulse burst having the proper number of pulses is required.

The burst is obtained by opening a gate for a carefully controlled length of time. The duration of this gate is determined by the Frequency Countdown which also determines the frequency of operation of the Unknown Capacitor to DC Converter as

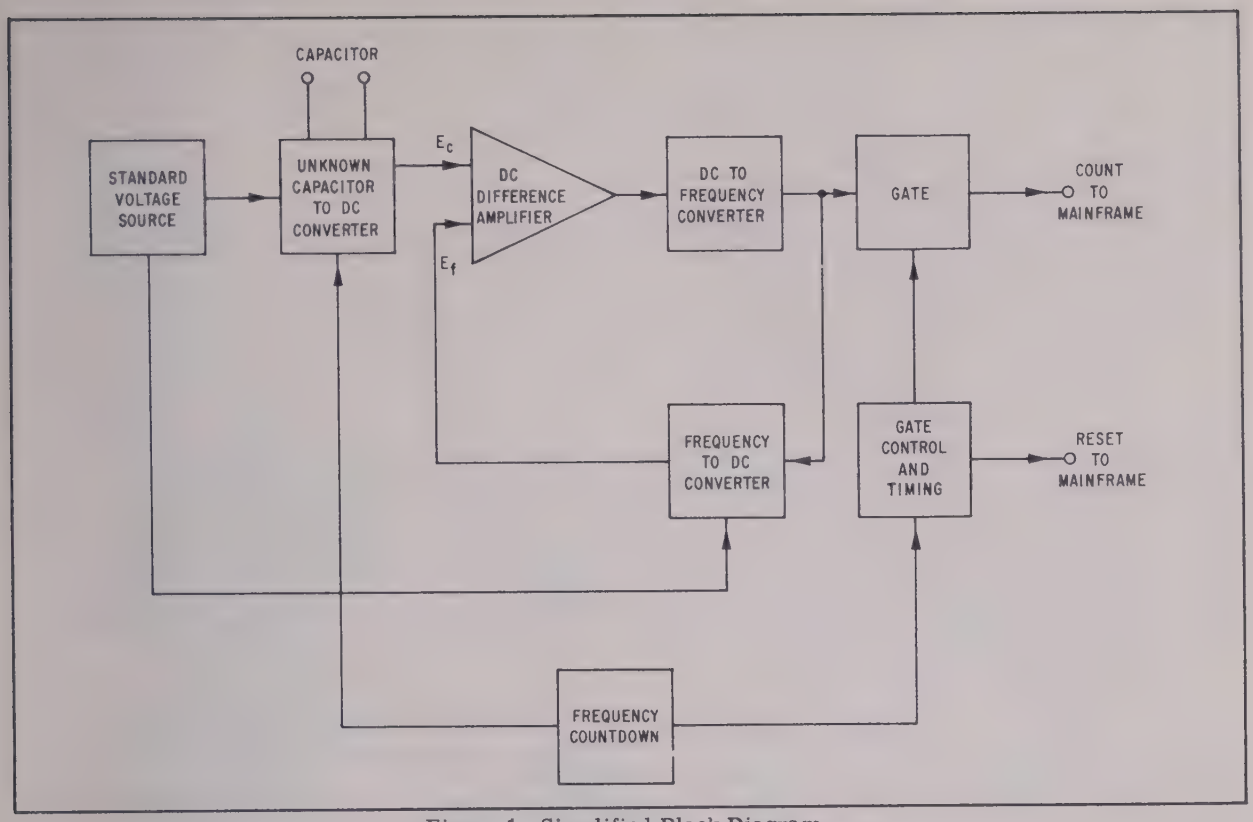


Figure 1. Simplified Block Diagram

previously noted. The effect of frequency drift in the Frequency Countdown has opposite effects on the two circuits involved. The opposite effects will exactly balance one another. As an example, if the Frequency Countdown frequency increases, the value of Ec will increase, thereby increasing the frequency of the output pulse train. However, an increase in frequency of the Frequency Countdown will shorten the duration of the gate, reducing the time in which pulses can enter the mainframe. The two effects balance one another such that the number of pulses entering the mainframe remains constant for a given capacitor under test.

The Gate Control and Timing circuit also produces a single pulse just prior to opening the gate which enters the Main Frame and resets the counting circuits to 000 OVERRANGE "Off", assuring that each measurement begins from 0.

Complete Block Diagram Circuit Operation

The Frequency Countdown:

The frequency countdown consists of four free running unijunction relaxation oscillators which are synchronized together. The first free running oscillator (Q26) (operating at about 5000 pps) determines the frequency of the total countdown. The next stage (Q27) divides Q26's frequency by 10. The following stage (Q28) divides Q27's frequency by 10. The last stage divides Q28's frequency by 5. The last stage also provides a sync pulse to the Display and Gate Time Generator.

The Unknown Capacitor Flip-Flop:

This flip-flop is driven via diode steering from the Frequency Countdown. The Range switch determines the frequency at which the flip-flop will operate. The flip-flop generates a square wave about 25 volts in amplitude, going from -20 volts to + 5 volts. This square wave is used to drive the FETs in the Charge- Discharge Switching.

The Switch Driver:

The switch drive is a single transistor amplifier driven by the Unknown Capacitor Flip-Flop. The amplifier drives the coil of a break-before-make, single pole, double throw switch. Signal to the amplifier is shorted out on the low capacitor ranges thereby keeping the switch inoperative.

The Charge-Discharge Switching:

The capacitor Charge-Discharge Switching actually consists of two switching arrangements -- a Field Effect Transistor switching arrangement is used on the low value ranges, and a break-before-make single pole, double throw switch is used for the high value ranges. The switching connects the Capacitor Source to the capacitor under test for one-half cycle and then connects the charged capacitor across a resistor to discharge for the second half cycle.

The Capacitor Source:

The capacitor source provides the standard

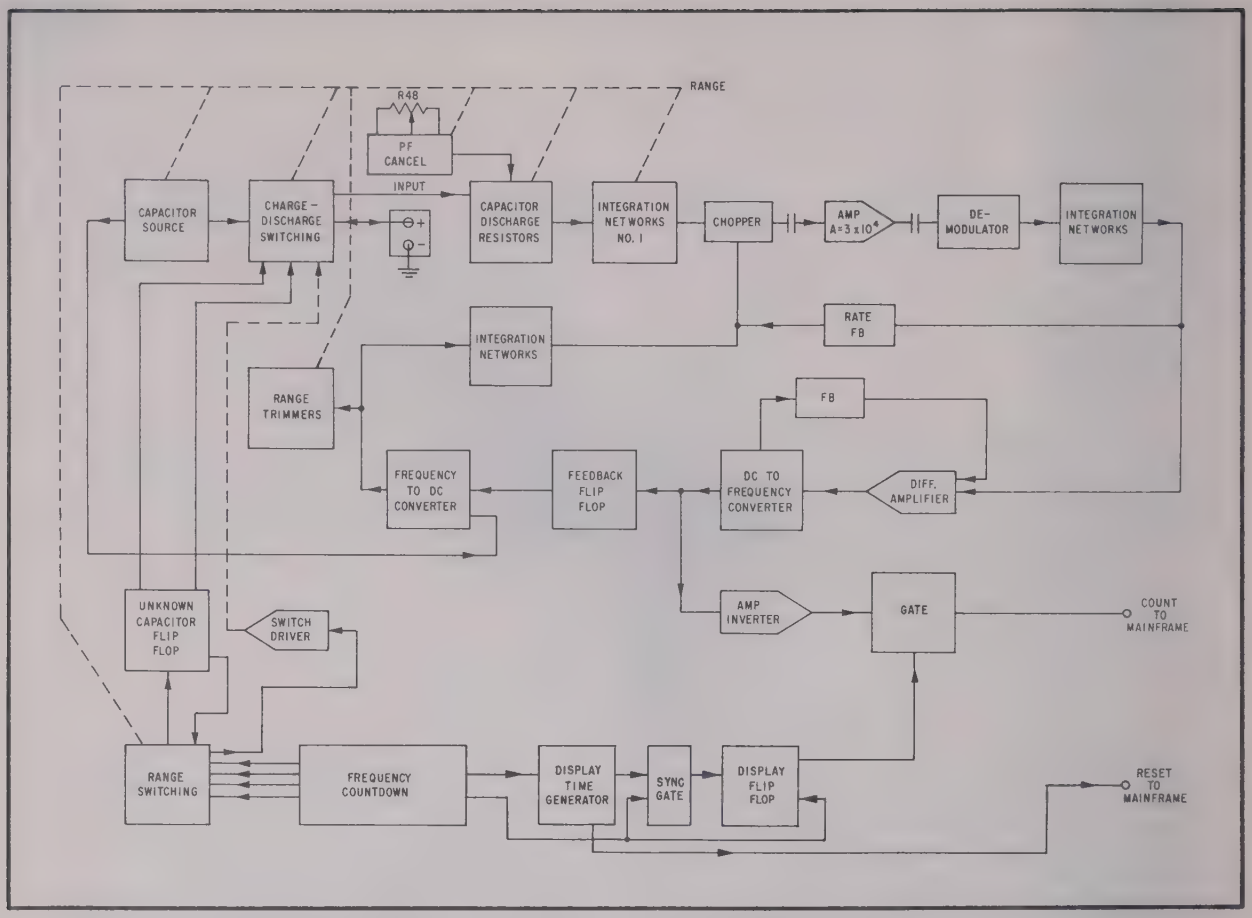


Figure 2. DP-200 Complete Block Diagram

charging voltage to the capacitor under test and to the Frequency to DC Converter. The source is a differential amplifier with dc feedback. The feedback is taken from one side and the output voltage is balanced against this source across a matched differential pair of transistors. Current is delivered to the capacitor under test until the capacitor charges up and the two inputs of the differential amplifier balance.

Capacitor Discharge Resistors:

The capacitor under test after being charged from the Capacitor Source is connected across a resistor to discharge. The pulse thus produced is integrated and becomes Ec in the Simplified Block Diagram. The resistor value is determined by the range setting.

Picofarad Cancel:

A negative voltage, as adjusted by R 55, is impressed across the capacitor discharge resistor for the range in use. This negates a portion of the voltage being produced by discharging the capacitor under test through this resistor. The cancel feature is used only on the XXX. picofarad range and the X.XX nanofarad range.

The Integration Network #1

The pulses produced across the capacitor discharge resistor are smoothed. Because the measuring circuitry is a true integrating system it is not necessary to remove all ac from the input voltage. The purpose of the integration network is to attenuate ac components of the input voltage enough to prevent loading and blocking the high gain DC difference amplifier.

The Chopper:

The chopper consists of 2 high speed photo resistors optically coupled by lucite "light pipes" to a neon tube multivibrator. The neon tubes are NE2U types, aged and matched. The frequency of the multivibrator is adjusted at the factory for about 135 cps. This chopper presents an ac signal to the following amplifier. The peak-to-peak value of the signal is nearly equal to the dc voltage across the chopper, Ec - Ef.

The Amplifier:

The Amplifier which follows the chopper has four stages. The amplifier uses an MOSFET to obtain a high impedance input and is direct coupled throughout.

To achieve stability, dc feedback is used with a moderate amount of ac voltage feedback and a considerable amount of ac current feedback derived from the Integrator. This causes the amplifier to appear as a current source when viewed from the Demodulator.

The Demodulator:

The Demodulator is similar to the chopper. It consists of high speed photo resistors activated by the same light source as the chopper. The cells are arranged such that a positive dc voltage appearing at the chopper inputs after amplification causes negative DC voltage on the Integrator.

The Integrator:

The Integrator consists of an RC filter section to smooth the demodulated dc. All output current from the Demodulator flows through R25. The voltage across R25 is then used to provide feedback to the amplifier. The smoothed dc output of the Integrator is about 4,000 times larger than the voltage (Ec-Ef) appearing across the chopper. The polarity of the output voltage is negative.

The Amp Inverter:

The amplifier inverter takes the square wave produced by the flip-flop, differentiates the waveform and amplifies it giving a series of negative going pulses. The frequency of these pulses is 1/2 the frequency of the DC to Frequency Converter output. These pulses are then fed through the Gate to the Main Frame counting circuits.

The Display Time Generator:

The Display Time Generator is a free running unijunction relaxation oscillator. It is synced to the last stage of the Frequency Countdowns. The frequency of oscillation is varied by the Display Pot and can be halted completely by pulling the Display knob out. When the unijunction fires a reset pulse is derived from a resistor in series with the emitter capacitor. This pulse is also coupled to the SYNC GATE.

The Sync Gate:

The Sync Gate is in series with pulses derived from the 50 cps countdown. In order to reach the Display Flip-flop to trigger it the pulses must be allowed to pass through the Sync Gate. The gate is normally closed. However when a reset pulse occurs the pulse is coupled to the gate and holds the gate open long enough for one pulse from the 50 cps countdown to enter the Display Flip-flop.

The Display Flip-flop:

The Display Flip-Flop is a monostable flip-flop. Pulses from the 50 cps Countdown are always coupled to the side which is normally on. Therefore the Flip-flop does not change states. When the Sync Gate allows a pulse to enter the normally off side of the Flip-flop, the Flip-flop will trigger. This opens the Gate. After a length of time determined by the R135, C43 combination the tenth pulse from the 50 cps Countdown following the pulse which triggered the flip-flop originally will carry Q33 into conduction and flip-flop will return to its original state. This closes the Gate.

Neon Trigger Circuit:

The Neon trigger circuit is comprised of an astable flip-flop and a pair of drivers which control the neons. The flip-flop runs at about 135 cps. When the flip-flop changes state it will turn the "on" driver off immediately. The "off" driver will not turn on immediately because of the R-C time delay circuit in the base of each driver. After a delay of approximately 1m sec the driver will turn on and the neon will turn on. The effect of this sequence is to provide a sequence in which, first, neon V5 is on and V6 is off; second, both neons are off; third, neon V6 is on and V5 is off; fourth, both neons are off. The cycle then repeats. The light output of the neons is coupled to the appropriate photocells.

SECTION V
SERVICE PROCEDURE

Servicing of the DP-200 plug-in should be undertaken only after the section of the manual entitled "Circuit Description" has been read and understood. Based on the simplified block diagram, the trouble-shooting procedure may be divided into six areas.

1. The Frequency Countdown including the Unknown Capacitor Flip-Flop. This area involves Q23, Q24 Q25, Q26, Q27, Q28, Q29.

2. The Gating Circuitry. This area involves Q27, Q30, Q31. Q32, Q33, Q34, Q35.

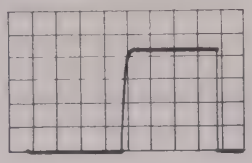
3. The Capacitor Under Test Circuitry. This area involves Q18, Q19, Q20, Q21, Q22.

4. The DC to Frequency Converter. This area involves Q10, Q11, Q12, Q13.

5. The DC Difference Amplifier. This area includes the photocells, and the amplifier, Q5, Q6, Q7, Q8, Q9, Q14, Q15, Q16, Q17.

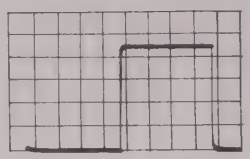
6. The Frequency to DC Converter. This area includes Q1, Q2, Q3, Q4.

Servicing can be most conveniently carried out by removing the back of the DMS-3200 and sliding out its



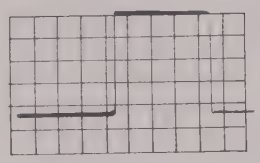
TEST POINT A

XXX. picofarad Range
Scope Settings
Horizontal .05 msec/div
Vertical 5 volts/div



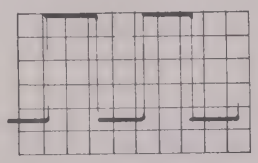
TEST POINT A

XX.X nanofarad Range
Scope Settings
Horizontal .5 msec/div
Vertical 5 volts/div



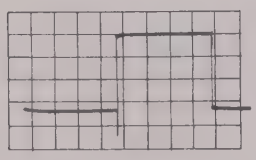
TEST POINT A

XXX. nanofarad Range
Scope Settings
Horizontal 5 msec/div
Vertical 5 volts/div



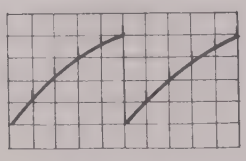
TEST POINT A

X.XX millifarad Range
Scope Settings
Horizontal 50 msec/div
Vertical 5 volts/div



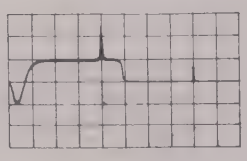
CAPACITOR TERMINALS

XX.X nanofarad Range
Scope Settings
Horizontal .5 msec/div
Vertical .5 volts/div



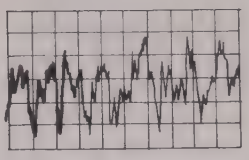
TEST POINT B

Scope Settings
Horizontal .1 sec/div
Vertical 2 volts/div



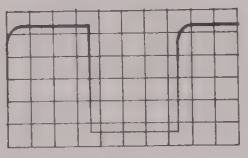
TEST POINT C

Scope Settings
Horizontal .5 msec/div
Vertical .5 volts/div



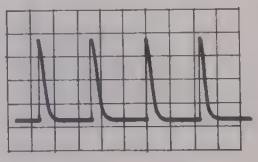
TEST POINT G

Scope Settings
Horizontal 10 msec/div
Vertical 1 volt/div



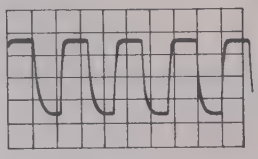
TEST POINT H

Scope Settings
Horizontal 2 msec/div
Vertical 2 volts/div



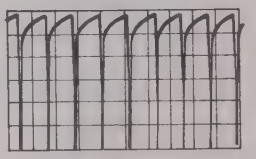
TEST POINT I

-.1 volts connected
to test point F
Scope Settings
Scope synce to collector Q4
Horizontal .1 msec/div
Vertical .5 volts/div



TEST POINT M

-.1 volts connected
to test point F
Scope Settings
Scope synced to collector Q4
Horizontal .1 msec/div
Vertical .5 volts/div

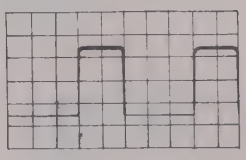


BASE 2 Q13

Test point E shorted to gnd
Scope Settings
Horizontal 50 msec/div
Vertical 1 volt/div

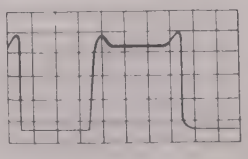
COLLECTOR Q2

Test point E shorted to gnd
Scope Settings
Horizontal .1 msec/div
Vertical 5 volts/div



TEST POINT R

Scope Settings
Horizontal .1 sec/div
Vertical 5 volts/div



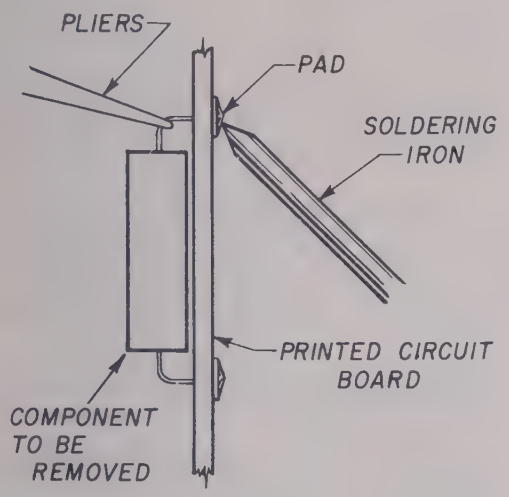
TEST POINT S

Scope Settings
Horizontal 2 msec/div
Vertical 20 volts/div

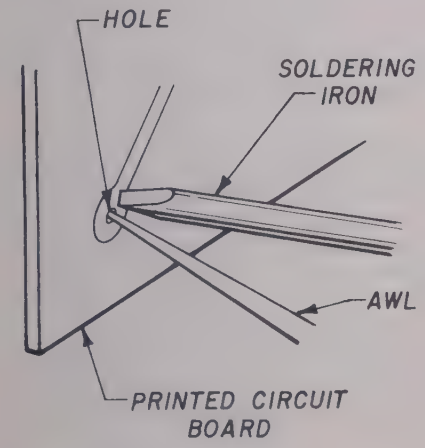
Figure 3. DP-200 Waveforms

PROCEDURE FOR REPLACING COMPONENTS

1. Hold board in either vertical position or horizontal position with print down. Apply heat sparingly to lead of component to be removed from print side of board. (Use a well tinned soldering iron). Remove component from board one lead at a time. It may require heating the leads alternately and "wiggling" the component out of the board.

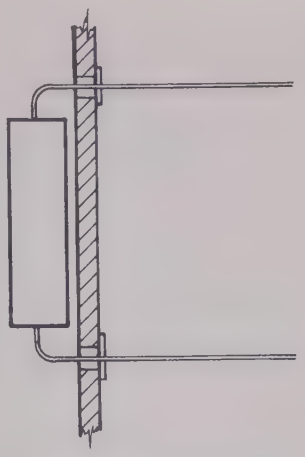


2. Reheat solder in hole and allow as much solder as possible to adhere to the soldering iron. Immediately insert an awl into the hole from the print side to clean out hole.



The above should be carefully followed or extensive damage to the printed circuit board will result. For many-leaded items, one lead at a time should be heated and withdrawn as far as possible, then do the same to the next lead in line, and so on until the component is "wiggled" loose.

3. Bend clean tinned leads of new component and carefully insert in holes. (Do not force component. If it does not insert easily reheat pad and clean as before).



4. Hold part to board and solder leads from print side of board. Do not leave a large blob of solder on pad. The correct amount can be determined by observing other connections made in production.

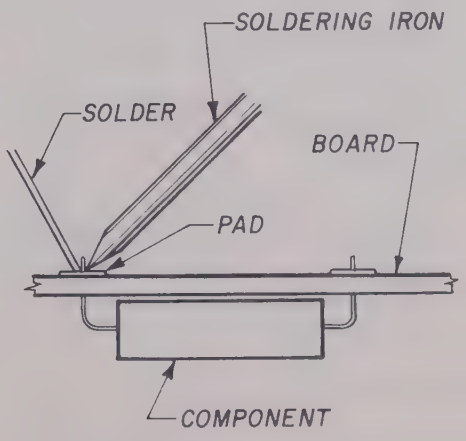


Figure 4. Servicing Etched Circuit Boards

bottom plate. Removing 2 screws will allow the bottom plate of the DP-200 to be slid out as well. With the DMS-3200 upside down and the DP-200 in place, easy access is provided to all adjustments and test points. Refer to Fig. 5 & 6 for the location of any part or test point. The pins of the plug-in connector are numbered on the connector body.

The Countdown Circuitry:

This circuitry may be serviced independently of the remaining blocks. The use of an oscilloscope with a triggered sweep and a 10 megohm probe is recommended. With the unit turned on, place the probe on Test Point A. Set the DP-200 to the XXX. picofarad range. The waveform should be as shown. If it is not, check Q23, Q24, Q26 and associated circuitry. Set the DP-200 to the XX. X nanofarad position. The waveform should be as shown. If it is not, check Q23, Q24, Q27, and associated circuitry. Set the DP-200 to the XXX. nanofarad position. The waveform should be as shown. If it is not, check Q23, Q24, Q28 and associated circuitry. Set the DP-200 to the X. XX millifarad position. The waveform should be as shown. If it is not, check Q23, Q24, Q29.

The timing of the countdown can be incorrect. This can be checked by noting the waveform on the cathode of the diodes connected to the capacitor which connects to the emitter of the various unijunction transistors. Setting of these countdowns is described in the calibration procedure, Section VI.

The Gating Circuitry:

This circuitry may be serviced independently of the remaining blocks. The use of an oscilloscope with a triggered sweep and a 10 megohm probe is recommended. with the unit turned on and the DISPLAY control fully CCW (be sure the knob is pressed in) Q30 should be operating as a synced relaxation oscillator. The waveform at Test Point B is shown in Figure 3.

Q30 should be synced to the last stage of the Countdown (Q29). The waveform at Test Point C is shown in Figure 3.

If Q30 and the flip-flop are operating properly check Q34. With the scope synced at Test Point B on the negative going wavefront the waveform at Test Point C should be as in Figure 3. With the scope synced to the same point as before the waveform shown in Figure 3 at Test Point R should be observed.

The Capacitor Under Test Circuitry:

This circuitry may be serviced independently of the remaining blocks. It is assumed that the Countdown circuitry is working properly. With the DP-200 set to the X. XX nanofarad range the waveform on the Capacitor terminals should be as shown in Figure 3. If the voltage is not proper check Q18, Q19, Q20. If the waveform is improper check Q21, Q22, CR10, and CR11.

If modifications are made in this circuitry the Calibration Procedure, Section VI should be followed. Normally standards of sufficient size and accuracy are not available in the field. Under these circumstances the unit should be returned to Hickok for recalibration.

The DC to Frequency Converter:

This circuitry may be serviced independently of the remaining blocks. However, it will be assumed that the gating circuitry is operating properly. Short Test Point E to ground. This should cause Q13 to free run at maximum frequency (10 Kc minimum). The waveforms are shown in Figure 3. If Q13 operates properly and no count appears on the DMS-3200, check Q34.

Disconnect the short from Test Point E. Connect a capacitor to the input terminals sufficient to drive the DP-200 to a full scale reading (999 approximately). The voltage at Test Point F should be about -. 1 volt. If it is different than -. 1 volt check the DC Difference Amplifier.

The DC Difference Amplifier:

The circuitry may be checked independently of the remaining circuitry. After allowing 1 minute for the ac amplifier to stabilize (C12 charges up through R20) check the DC voltage at Test Point G. It should be between + 70 and + 100 vdc. Note that Q1 is a metal-oxide-silicon field effect transistor. It should not be replaced or otherwise disturbed in the field. The dc feedback loop and Q2 insure the proper biases. Normally, very little 60 cps signal will be observed at Test Point G. Figure 3 shows the wave shape typically found at Test Point G with the DP-200 operating normally. Because of high noise level, it is best to sync the scope from Test Point H whenever it is desired to observe a signal at test point G.

To check the input modulator photocells, connect a capacitor to the Capacitor terminals sufficient to obtain a full scale reading and short Test Point I to ground. Then with a sensitive high impedance DC voltmeter, measure the voltage at Test Point J. The normal range of voltage is between 45 and 55 mv. At Test Point K, the normal range is from 23. 5 to 27. 5 mv. At Test Point L, the normal range is from 0 to 10 mv. If these readings are not obtained, then the input photocells, V1, V2 must be replaced. Be very careful to avoid heating these cells. ALWAYS USE A HEAT SINK WHEN SOLDERING PHOTOCELLS.

The waveform at Test Point S should be as shown in the Figure 3. If it is not check the waveform at Test Point H to see if it is acting as an astable multivibrator operating at about 135 cps. If it is check the bases of Q14 and Q17 determining if the signal is reaching the bases. If signal appears at the bases but the signal at the Test Point S does not approximate that shown in Figure 3 the driver transistors, Q14 and Q17, are probably at fault.

The Frequency to DC Converter:

Connect a -. 1 volt source to Test Point F. This should cause Q13 to run at about 10 Kc. Now check for the wave forms of Figure 3. Make sure the flip-flop (Q1 and Q2) is working correctly.

If the Flip-flop is working properly, check Q3, Q4, CR3 and CR4. The waveforms should be as noted in Figure 3 for Test Points M, N, I.

SECTION VI
CALIBRATION PROCEDURE

Equipment:

1 10:1 probe

1 DP-150, DMS-3200 counter or equivalent

1 General Radio Standard Decade Capacitor 100 pf to 1. 111 uF ± . 05% or equivalent

1 Standard Capacitor 1 uF to 999 uF . 05%

1 DC Voltmeter (Hickok DP-100 or equivalent)

NOTE

DP-200 TO BE CALIBRATED SHOULD BE THOROUGHLY CLEANED AND DRIED PER CLEANING PROCEDURE, PARAGRAPH 20.

THIS PROCEDURE IS TO BE PERFORMED IN AN AMBIENT TEMPERATURE OF 25° C ± 2° C ONLY.

CALIBRATION

1. Plug the plug-in to be calibrated into DMS-3200 main frame which has its bottom cover plate removed. With the bottom plate of the plug-in removed all adjustments and test points may be easily reached. Refer to the schematic.
2. Turn on DMS-3200
3. Connect a counter such as the DP-150, via a 10:1 probe to Test Point H Adjust R48 for a frequency of 130 to 140 cps with 135 cps preferred.
4. Set DP-200 to the XXX. nano-farad range. Using a scope, check amplifier output bias level at Test Point G. The voltage level should be from 70 to 100 volts.
5. a. Connect a test lead to the can of Q26 and another test lead to the chassis of the DP-200 to be calibrated.

   b. Set the DP-200 range to picofarads. Connect a DP-150 via a 10:1 scope probe to pin 5 on the rear of the 3rd deck of the range switch. Set the DP-150 controls as follows:

Input	+
Function	XX. X "KC"
Sensitivity	adjust for minimum sensitivity for reliable reading
Display	comfortable rate

6. a. Connect one of the calibration resistors between the two test leads. Turn on the DP-200. Note the reading on the DP-150. Warm the can of Q26 with a soldering iron or other suitable tool. (Do not overheat.) Note the new DP-150 reading.

   b. If the DP-150 reading became greater, choose a larger resistor and repeat the procedure above. If the DP-150 reading became smaller, choose a smaller resistor and repeat the procedure above.

   c. Continue in this manner until a value of resistor is determined which minimizes the change.

   d. Place the resistor determined in Step C into the proper space on the P.C. board and solder it into place.

   e. Adjust R96 until a reading 5. 00 Kc is obtained on the DP-150. Secure R96.

7. Set the DP-200 to XX. X nano-farads.
8. a. Set R92 fully clockwise.

   b. Set the DP-150 function to XXX. "cps".

   c. Adjust R103 CCW until the DP-150 gives a reading of 500 cps. Do not turn R103 past this point.

   d. Measure the voltage from Point 0 to the + 20V supply. A DP-100 is good for this purpose (set to the -10 range). This voltage is the upper limit voltage.

   e. Now turn R103 further CCW. At some point, the reading will jump to 455 cps (approx.). From this point, adjust R103 slightly CW until the reading returns to a steady 500 cps.

   f. Again (as in Step d) measure the voltage from Point 0 to the + 20V supply. This is the Lower Limit Voltage.

   g. Subtract the lower limit voltage from the Upper Limit Voltage.

   h. Add now, 1/2 the difference found in Step g to the Lower Limit Voltage.

   i. Now adjust R103 until the voltage measured from Point 0 to the + 20V supply is exactly equal to the voltage calculated and written down in Step g.

   j. Finally, place a drop of fingernail polish on the pot so that the adjustment is secured.

9. a. Set the DP-200 to the XXX. nanofarads position.

   b. Set DP-150 as follows:

Function	XX. X "ms"
Sensitivity	Readjust if necessary

c. The procedure for finding Upper Limit Voltage and Lower Limit Voltage is essentially the same as Part 8 above. The measurements are made from Point P to the + 20. 0 ms.

d. The Lower Limit Voltage is found as in Step 8c above.

10. a. Set the DP-200 Range to the millifarads position.

b. The DP-150 settings remain the same.

c. The procedure for finding the Upper Limit Voltage and Lower Limit Voltage is essentially the same as in Step 8 above. The readings are taken from Point Q to the + 20V supply. The Upper Limit Voltage is obtained when the reading changes to 100. 0 ms.

d. The Lower Limit Voltage is found as in Step 8c above.

11. a. Set the DP-200 to the XXX. nano-farad range.

b. Connect the S.D.C. to the input. Set the S.D.C. to . X001.

c. Connect the DP-100 to Test Point T.

d. Adjust R136 until the DP-200 reads between 001 "overrange on" to 075 "overrange on".

e. Following a similar procedure to the countdown setting adjust the pot CW to a point where the reading will switch about 100 digits. Adjust back until the reading is stable, and within the limits stated above. Note the reading of the DP-100.

f. Adjust the pot CCW to a point where the reading switches about 100 digits. Adjust back until the reading is stable, as above. Note the DP-100 reading. Take the difference of the two readings, divide by 2, and add this number to the lower reading.

g. Adjust R136 until the DP-100 reads the voltage just determined. Secure R136. This completes setting of the frequency countdowns. Remove all test equipment from the DP-200.

12. a. Set the DP-200 as follows:

RANGE - XX. X nano-farads
DISPLAY - comfortable rate

b. Connect the General Radio SDC to the input. Set the SDC to . 1401 uF.

c. Set R70 to the center of its range.

d. Select one or a combination of three of the available calibration capacitors which set the reading of the DP-200 closest to 401 "overrange on". The calibration capacitors are placed in the holes provided in the board for C5, C6 and C7. Place selected capacitors in board properly and solder in place.

13. a. Disconnect the DP-200 input from everything.

b. Set the DP-200 to the XXX. picofarad range.

c. Set the Picofarad Cancel maximum CCW.

d. Adjust R53 for a reading of 008 ± 1 digit.

14. a. Set the SDC to . 0001 uF. and connect it to the DP-200 input.

b. Set the DP-200 to the XXX. picofarad range.

c. Adjust the Picofarad Cancel for a reading of 100 on the DP-200.

d. Set the SDC to . 0014 uF.

e. Adjust R69 for a reading of 400 "overrange on" on the DP-200.

f. Set the SDC to .0001 uF. If necessary readjust the Picofarad Cancel to a reading of 100 and repeat Steps d and e above.

15. a. Set the DP-200 to the XX.X nanofarad position.

b. Set the SDC to . 1401 uF.

c. Adjust R70 for a reading of 401 "overrange on".

16. a. Set the SDC to . 0141 uF.

b. Set the DP-200 to the X.XX nanofarad position.

c. The reading should be 410 ±1 digit "overrange on" (If it is not, check R70 setting or the countdown).

17. a. Set the DP-200 to XXX. nanofarad position.

b. Set the SDC to . XXX uF position.

c. The reading should be 111 ±1 digit "overrange on". (If it is not, check countdown or R70 setting.)

18. a. Set the DP-200 to the X. XX microfarad position.

b. Connect the DP-200 input to the 1 uF to 999 uF standard.

c. Set the 1 uF to 999 uF standard to 14. 00 uF.

d. Adjust R71 until the DP-200 reads 4. 00 uF "overrange on".

19. a. Set the DP-200 to the XX.X microfarad position.

b. Set the 1 uF to 999 uF standard to 140. 0 uF.

c. Adjust R72 until the DP-200 reads 40. 0 uF "overrange on".

20. a. Set the DP-200 to the XXX. microfarad position.

b. Set the 1 uF to 999 uF standard to 999 uF.

c. Adjust R73 until the DP-200 reads 999. "over-range off".

21. a. Set the DP-200 to the X.XX millifarad position.

b. The reading should be 100 ±1 digit.

22. Remove light rods from DP-200 chopper. Dip DP-200 in clean anhydrous 2-isopropanol up to, but not including, switch detents. Shake excess isopropanol from unit and allow the unit to dry in free air. Then dip the unit in Freon TF with DC-200 added. Allow the unit to air dry. As soon as dry install the light rods taking care to keep fingers and tools from touching board surface or components or switches. Immediately install the top and bottom covers and secure the unit.

23. Plug the unit into a DMS-3200 and allow a 2 hour warmup.

24. Repeat Steps 12, 13, 14, 15, 16, 17, 18, 19 to check calibration. Readjust if necessary, being careful to keep fingers, etc., from inside unit and resecure all pots.

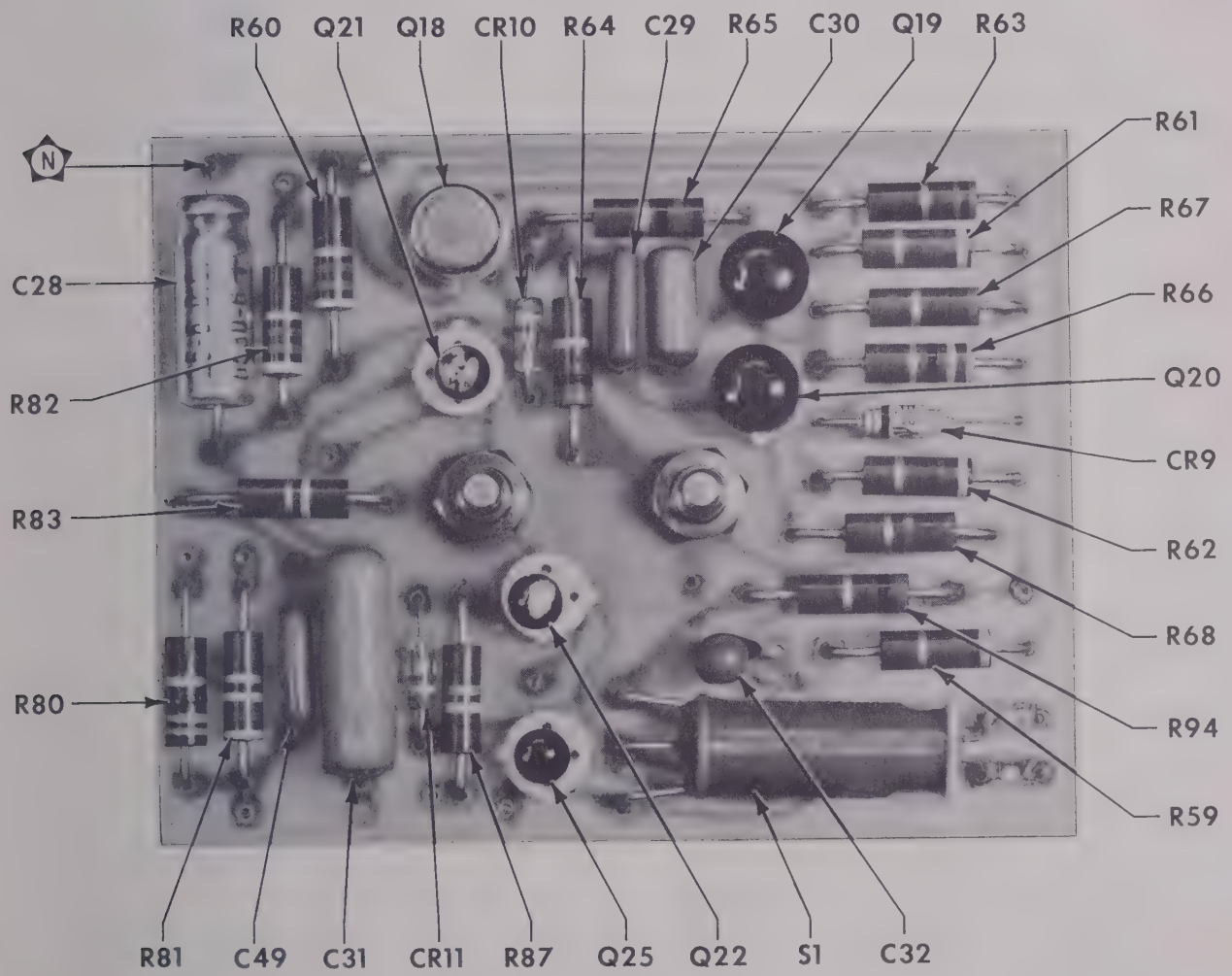


Figure 5. Component Locations - Unknown Capacitor Board

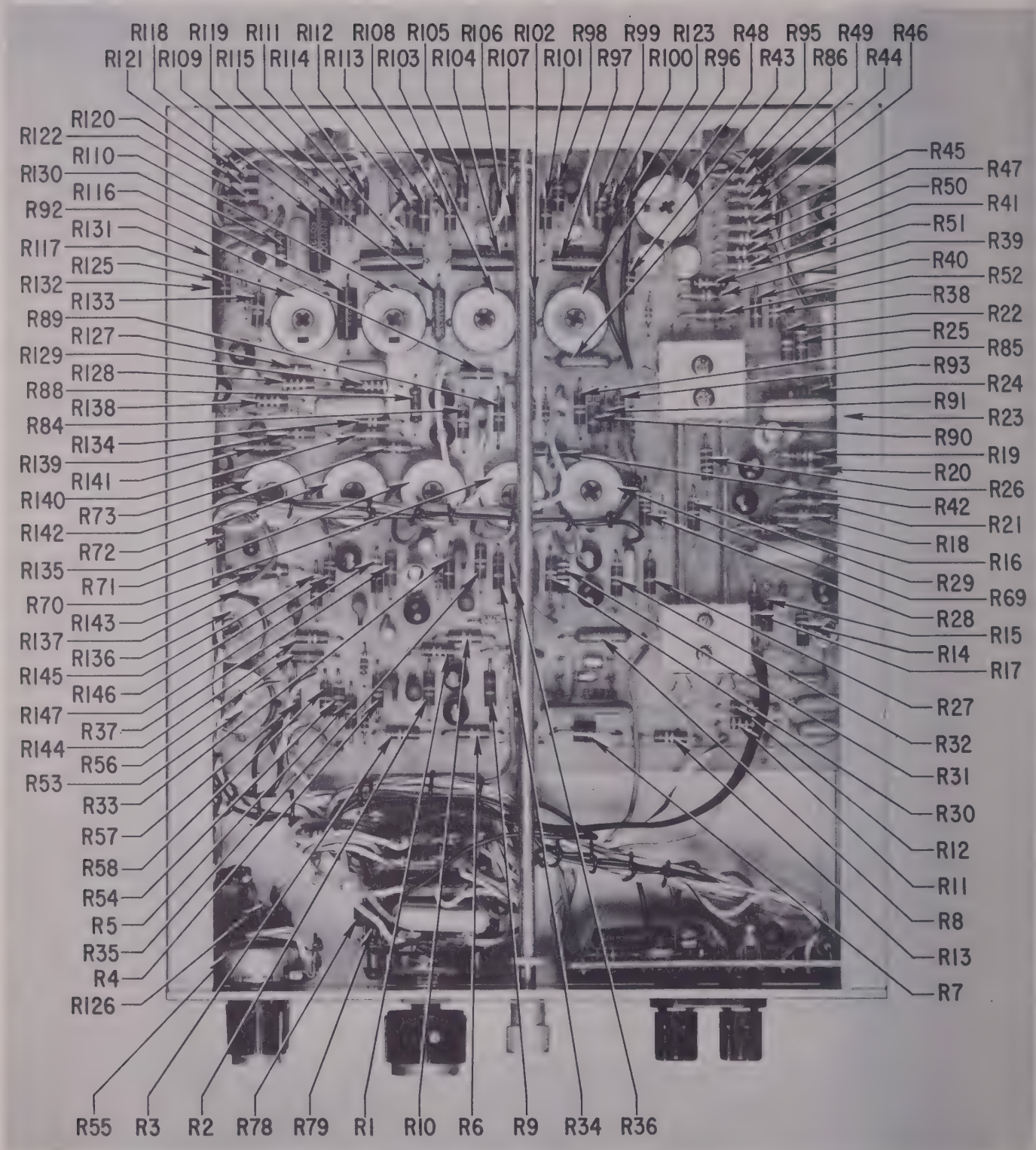


Figure 6. Component Locations (Sheet 1 of 2)
Resistors only

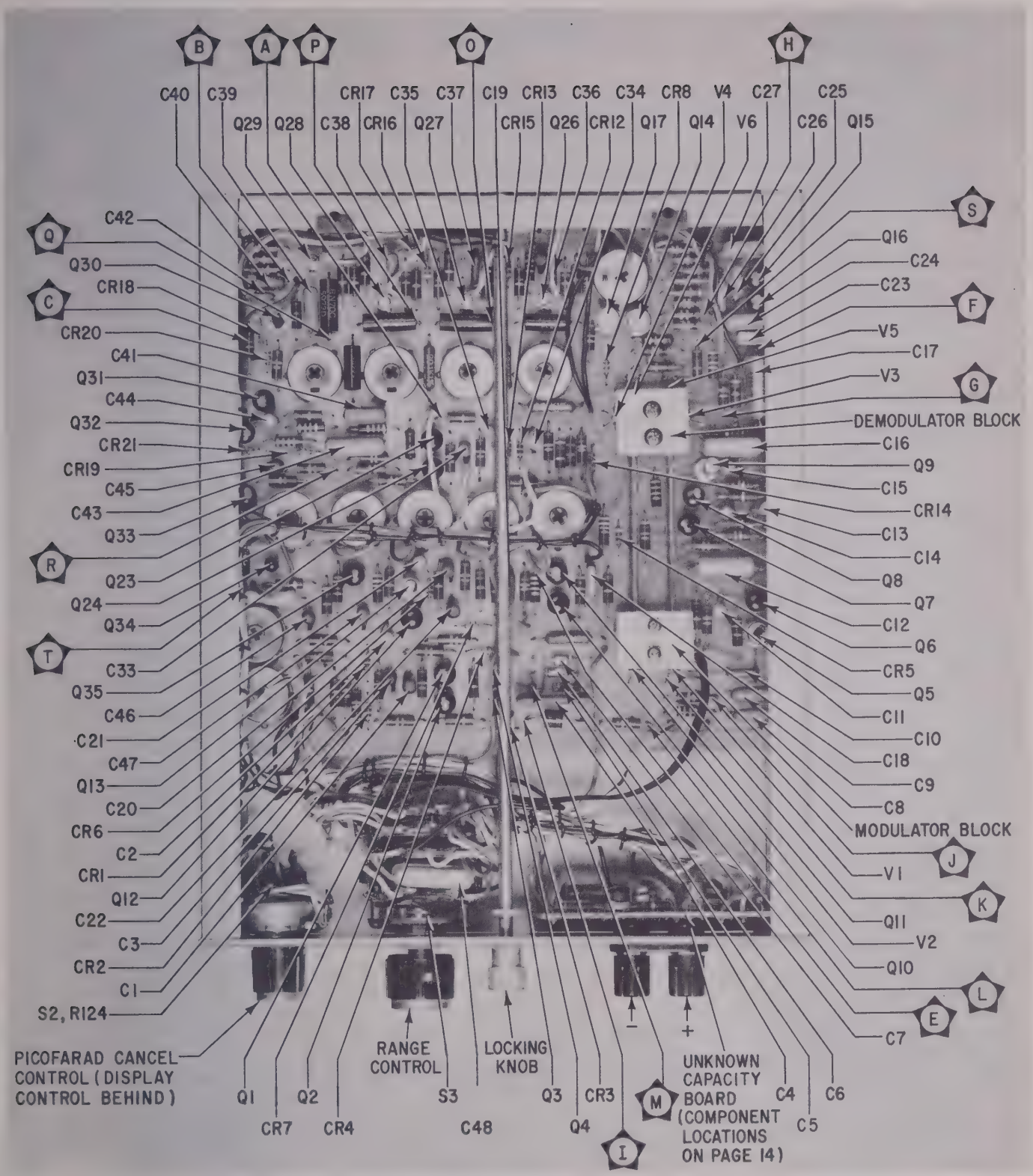


Figure 6. Component Locations (Sheet 2 of 2)
Other components

SECTION VII
PARTS LIST

INTRODUCTION

Reference designations are assigned to identify all parts of the Model DP-200 Capacitor Plug-In. These designations are used in the parts list and the schematic wiring diagram. The letter prefix of a reference designation indicates the kind of part - resistor, capacitor, semiconductor, etc. The number differentiates between parts in the same group.

REF. DESIG.	NAME AND DESCRIPTION	HICKOK PART NO.	PRICE EACH
C1	CAPACITOR, FIXED, CERAMIC: 100pf, 20%, 500V	3111-516	.50
C2	CAPACITOR, FIXED, CERAMIC: 470pf, 20%, 500V	3111-520	.50
C3	Same as C1		
C4	CAPACITOR, FIXED: 5000pf ±1%, radial leads, cement insulated	3103-37	.99
C5	CAPACITOR, FIXED, POLYSTYRENE: Calibration, 10%, 160V, exact value determined in production		
C6	Same as C5		
C7	Same as C5		
C8	CAPACITOR, FIXED, POLYCARBONATE FILM: .1uf, 10%, 400V	3092-413	.55
C9	Same as C8		
C10	CAPACITOR, FIXED, POLYCARBONATE FILM: .01μf, 10%, 400V	3092-401	.55
C11	CAPACITOR, FIXED, CERAMIC: 47pf, 20%, 500V	3111-514	.50
C12	CAPACITOR, FIXED, ELECTROLYTIC: 100μf, 20%, 12V	3085-282	1.12
C13	Same as C2		
C14	CAPACITOR, FIXED, CERAMIC: 330pf, 20%, 500V	3111-519	.50
C15	Same as C14		
C16	CAPACITOR, FIXED, POLYESTER FILM: .47μf, 10%, 200V	3092-221	.55
C17	CAPACITOR, FIXED, ELECTROLYTIC: 150μf, 3V	3085-310	1.48
C18	CAPACITOR, FIXED, POLYESTER FILM: .047μf, 10%, 200V	3092-209	.55
C19	CAPACITOR, FIXED, POLYESTER FILM: .1μf, 10%, 200V	3092-213	.55
C20	CAPACITOR, FIXED, CERAMIC: 1000pf, +50% -20%, 500V	3111-522	.50
C21	Same as C2		
C22	Same as C1		
C23	Same as C18		
C24	CAPACITOR, FIXED, POLYESTER FILM: .22μf, 10%, 200V	3092-217	.55
C25	CAPACITOR, FIXED, POLYESTER FILM: .022μf, 10%, 200V	3092-205	.55
C26	Same as C25		
C27	Same as C24		
C28	CAPACITOR, FIXED, ELECTROLYTIC: 22μf, 6V, tolerance 10% to +100%, axial wire leads	3085-295	.80
C29	CAPACITOR, FIXED, POLYESTER FILM: .01μf, 10%, 200V	3092-201	.55
C30	Same as C19		
C31	CAPACITOR, FIXED, POLYCARBONATE FILM: .22μf, 10%, 400V	3092-417	.55
C32	Same as C20		
C33	Same as C14		
C34	Same as C2		
C35	Same as C14		

REF. DESIG.	NAME AND DESCRIPTION	HICKOK PART NO.	PRICE EACH
C36	Same as C29		
C37	Same as C29		
C38	Same as C19		
C39	Same as C24		
C40	CAPACITOR, FIXED, ELECTROLYTIC: tantalum, 5.0μf, 20%, 20V, epoxy case	3085-269	1.00
C41	Same as C24		
C42	Same as C29		
C43	Same as C16		
C44	CAPACITOR, FIXED, CERAMIC: .0047μf, +50% -20%, 500V	3111-526	.50
C45	Same as C1		
C46	Same as C20		
C47	CAPACITOR, FIXED, CERAMIC: 22pf, 20%, 500V	3111-512	.50
C48	CAPACITOR, FIXED, POLYESTER FILM: 1μf, 10%, 200V	3092-225	.50
C49	CAPACITOR, FIXED, POLYCARBONATE FILM: .047μf, 10%, 400V	3092-409	.55
CR1	SEMI-CONDUCTOR DEVICE, DIODE: 1N914	3870-175	.66
CR2	Same as CR1		
CR3	SEMI-CONDUCTOR DEVICE, GERMANIUM DIODE: 20V PIV, 1N695	3870-179	.66
CR4	Same as CR3		
CR5	Same as CR1		
CR6	Same as CR1		
CR7	Same as CR1		
CR8	Same as CR1		
CR9	SEMI-CONDUCTOR DEVICE, ZENER DIODE: 6.8V ±5%, 1N710A	3870-178	1.52
CR10	Same as CR3		
CR11	Same as CR3		
CR12	Same as CR1		
CR13	Same as CR1		
CR14	Same as CR1		
CR15	Same as CR1		
CR16	Same as CR1		
CR17	Same as CR1		
CR18	Same as CR1		
CR19	Same as CR1		
CR20	Same as CR1		
CR21	Same as CR1		
Q1	TRANSISTOR: 2N3566 NPN silicon general purpose	20861-122	.89
Q2	Same as Q1		
Q3	TRANSISTOR: FET 2N4304N channel	20861-116	3.57
Q4	Same as Q3		
Q5	TRANSISTOR: MOSFET (Amplifier)	20861-102 or 20861-104	6.04

REF. DESIG.	NAME AND DESCRIPTION	HICKOK PART NO.	PRICE EACH
Q6	Same as Q1		
Q7	Same as Q1		
Q8	Same as Q1		
Q9	TRANSISTOR: 40354 NPN silicon high voltage	20861-114	2.27
Q10	Same as Q1		
Q11	Same as Q1		
Q12	Same as Q1		
Q13	TRANSISTOR: Unijunction 2N4852	20861-130	2.24
Q14	TRANSISTOR: A130 NPN silicon high voltage	20861-77	1.37
Q15	Same as Q1		
Q16	Same as Q1		
Q17	Same as Q14		
Q18	TRANSISTOR: Differential pair, NPN silicon A646	20861-117	6.60
Q19	TRANSISTOR: 2N3638 PNP silicon general purpose	20861-65	.98
Q20	Same as Q19		
Q21	Same as Q3		
Q22	Same as Q3		
Q23	Same as Q1		
Q24	Same as Q1		
Q25	Same as Q1		
Q26	Same as Q13		
Q27	Same as Q13		
Q28	Same as Q13		
Q29	Same as Q13		
Q30	Same as Q13		
Q31	Same as Q1		
Q32	Same as Q1		
Q33	Same as Q1		
Q34	TRANSISTOR: 2N3640 PNP silicon high frequency	20861-72	1.32
Q35	Same as Q1		
R1	RESISTOR, FIXED, COMPOSITION: 12K ohms, 10%, 1/2 W	18413-122	.46
R2	RESISTOR, FIXED, COMPOSITION: 100K ohms, 10%, 1/2 W	18414-102	.46
R3	Same as R1		
R4	Same as R2		
R5	RESISTOR, FIXED, COMPOSITION: 10K ohms, 10%, 1/2 W	18413-102	.46
R6	RESISTOR, FIXED, COMPOSITION: 220K ohms, 10%, 1/2 W	18414-222	.46
R7	RESISTOR, FIXED, WIRE WOUND: 1.04K ohms, ± .5%, ± 20ppm temp. coeff.	18525-909	.58
R8	RESISTOR, FIXED, METAL FILM: 10K ohms, 1%, 1/2 W	18525-910	.58
R9	RESISTOR, FIXED, COMPOSITION: 5.6K ohms, 10%, 1/2 W	18412-562	.46
R10	Same as R6		
R11	RESISTOR, FIXED, COMPOSITION: 470K ohms, 10%, 1/2 W	18414-472	.46

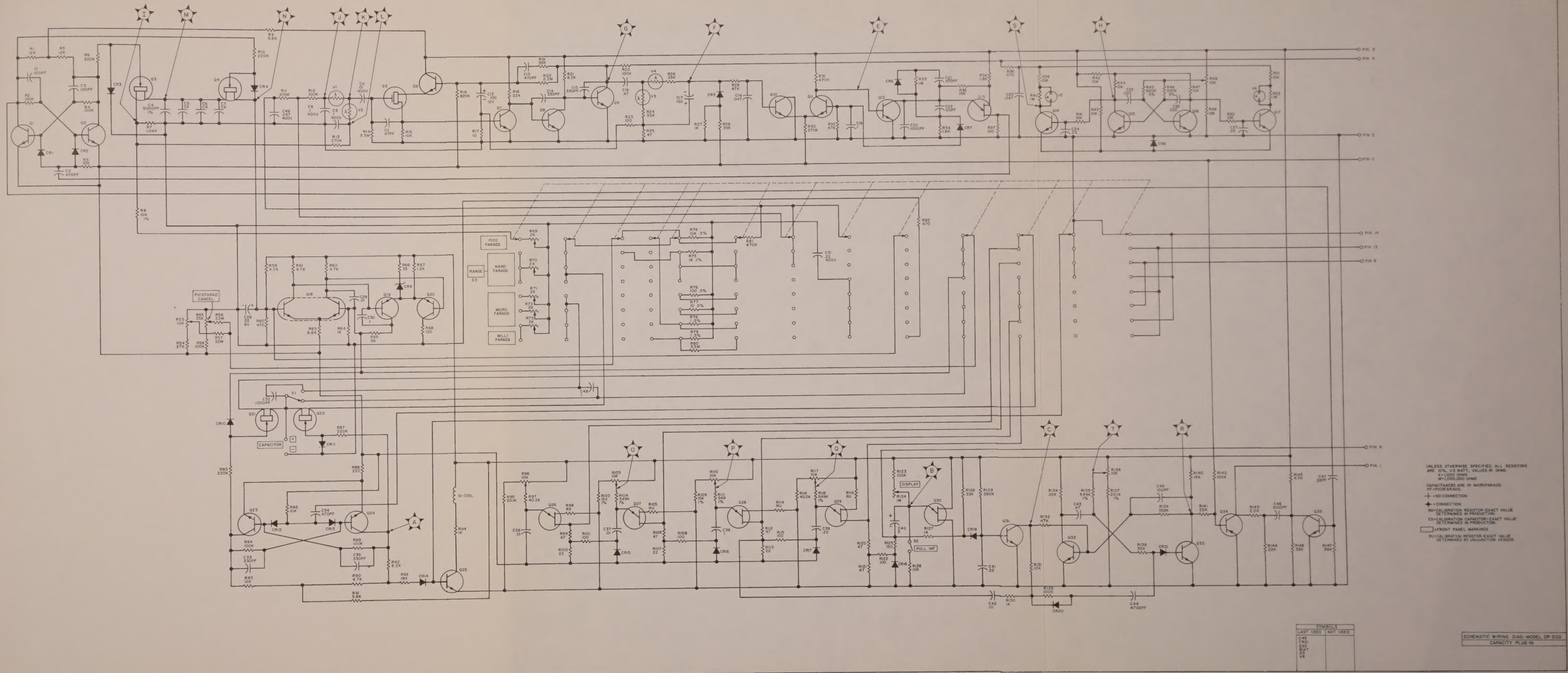
REF. DESIG.	NAME AND DESCRIPTION	HICKOK PART NO.	PRICE EACH
R12	Same as R2		
R13	RESISTOR, FIXED, COMPOSITION: 270K ohms, 10%, 1/2 W	18414-272	.46
R14	RESISTOR, FIXED, COMPOSITION: 3.3 megohms, 10%, 1/2 W	18415-332	.46
R15	Same as R5		
R16	RESISTOR, FIXED, COMPOSITION: 820K ohms, 10%, 1/2 W	18414-822	.46
R17	RESISTOR, FIXED, COMPOSITION: 10 ohms, 10%, 1/2 W	18410-102	.46
R18	RESISTOR, FIXED, COMPOSITION: 22K ohms, 10%, 1/2 W	18413-222	.46
R19	RESISTOR, FIXED, COMPOSITION: 56K ohms, 10%, 1/2 W	18413-562	.46
R20	RESISTOR, FIXED, COMPOSITION: 2.2 megohms, 10%, 1/2 W	18415-222	.46
R21	RESISTOR, FIXED, COMPOSITION: 8.2K ohms, 10%, 1/2 W	18412-822	.46
R22	Same as R2		
R23	RESISTOR, FIXED, COMPOSITION: 100 ohms, 10%, 1/2 W	18411-102	.46
R24	RESISTOR, FIXED, COMPOSITION: 33K ohms, 10%, 1/2 W	18413-332	.46
R25	RESISTOR, FIXED, COMPOSITION: 47 ohms, 10%, 1/2 W	18410-472	.46
R26	Same as R24		
R27	RESISTOR, FIXED, COMPOSITION: 1K ohms, 10%, 1/2 W	18412-102	.46
R28	RESISTOR, FIXED, COMPOSITION: 39K ohms, 10%, 1/2 W	18413-392	.46
R29	RESISTOR, FIXED, COMPOSITION: 47K ohms, 10%, 1/2 W	18413-472	.46
R30	Same as R13		
R31	Same as R11		
R32	Same as R29		
R33	RESISTOR, FIXED, COMPOSITION: 1 megohm, 10%, 1/2 W	18415-102	.46
R34	RESISTOR, FIXED, COMPOSITION: 1.8K ohms, 10%, 1/2 W	18412-182	.46
R35	RESISTOR, FIXED, COMPOSITION: 15K ohms, 10%, 1/2 W	18413-152	.46
R36	Same as R34		
R37	Same as R23		
R38	Same as R29		
R39	Same as R5		
R40	Same as R33		
R41	Same as R5		
R42	Same as R5		
R43	Same as R5		
R44	Same as R5		
R45	RESISTOR, FIXED, COMPOSITION: 620K ohms, 5%, 1/2 W	18414-621	.46
R46	Same as R45		
R47	Same as R5		
R48	RESISTOR, VARIABLE, WIRE WOUND: 10K ohms, 20%, 2 W	16925-569	.78
R49	Same as R5		
R50	Same as R5		
R51	Same as R5		
R52	Same as R33		

REF. DESIG.	NAME AND DESCRIPTION	HICKOK PART NO.	PRICE EACH
R53	Same as R48		
R54	RESISTOR, FIXED, COMPOSITION: 27K ohms, 10%, 1/2 W	18413-272	.46
R55	RESISTOR, VARIABLE, COMPOSITION: 25K ohms, 20%, 1/2 W, linear taper	16925-545	.78
R56	RESISTOR, FIXED, COMPOSITION: 22 megohms, 10%, 1/2 W	18416-222	.40
R57	Same as R56		
R58	Same as R2		
R59	RESISTOR, FIXED, COMPOSITION: 4.7K ohms, 10%, 1/2 W	18412-472	.46
R60	RESISTOR, FIXED, COMPOSITION: 470 ohms, 10%, 1/2 W	18411-472	.46
R61	Same as R59		
R62	Same as R59		
R63	RESISTOR, FIXED, COMPOSITION: 6.8K ohms, 10%, 1/2 W	18412-682	.46
R64	Same as R27		
R65	RESISTOR, FIXED, COMPOSITION: 56 ohms, 10%, 1/2 W	18410-562	.46
R66	RESISTOR, FIXED, COMPOSITION: 33 ohms, 10%, 1/2 W	18410-332	.46
R67	RESISTOR, FIXED, COMPOSITION: 1.2K ohms, 10%, 1/2 W	18412-122	.46
R68	RESISTOR, FIXED, COMPOSITION: 120 ohms, 10%, 1/2 W	18411-122	.46
R69	RESISTOR, VARIABLE, WIRE WOUND: 2K ohms, 20%, 2 W	16925-568	.70
R70	Same as R69		
R71	Same as R69		
R72	Same as R69		
R73	Same as R69		
R74	RESISTOR, FIXED, WIRE WOUND: 10K ohms, ± .5%, ±20 ppm temp. coeff.	18525-904	1.02
R75	RESISTOR, FIXED, WIRE WOUND: 1K ohms, ± .1%, ±20 ppm temp. coeff.	18525-905	1.02
R76	RESISTOR, FIXED, WIRE WOUND: 100 ohms, ± .5%, ±20 ppm temp. coeff.	18525-906	1.02
R77	RESISTOR, FIXED, WIRE WOUND: 10 ohms, ± .5%, ±20 ppm temp. coeff.	18525-907	1.02
R78	RESISTOR, FIXED, WIRE WOUND: 1 ohm, ± .5%, ±20 ppm temp. coeff.	18525-908	1.02
R79	Same as R78		
R80	Same as R14		
R81	Same as R11		
R82	Same as R60		
R83	Same as R6		
R84	Same as R2		
R85	Same as R1		
R86	Same as R5		
R87	Same as R6		
R88	RESISTOR, FIXED, COMPOSITION: 220 ohms, 10%, 1/2 W	18411-222	.46
R89	Same as R2		
R90	Same as R59		
R91	Same as R9		
R92	Same as R21		
R93	RESISTOR, FIXED, COMPOSITION: 18K ohms, 10%, 1/2 W	18413-182	.46

REF. DESIG.	NAME AND DESCRIPTION	HICKOK	PRICE
R94	Same as R27		
R95	RESISTOR, FIXED, METAL FILM: 20.1K ohms, 1%, 1/2 W	18525-875	.58
R96	Same as R48		
R97	RESISTOR, FIXED, METAL FILM: 40.2K ohms, 1%, 1/2W	18525-876	.58
R98	RESISTOR, FIXED, COMPOSITION: 5%, 1/2W, calibration, exact value determined in production		
R99	Same as R25		
R100	RESISTOR, FIXED, COMPOSITION: 22 ohms, 10%, 1/2W	18410-222	.46
R101	Same as R23		
R102	RESISTOR, FIXED, METAL FILM: 15K ohms, 1%, 1/2W	18525-916	.58
R103	Same as R48		
R104	RESISTOR, FIXED, METAL FILM: 549K ohms, 1%, 1/2W	18525-915	.58
R105	RESISTOR, FIXED, COMPOSITION: 5%, 1/2W, exact value determined by unijunction transistor vendor		
R106	Same as R25		
R107	Same as R100		
R108	Same as R23		
R109	Same as R102		
R110	Same as R48		
R111	Same as R104		
R112	Same as R25		
R113	Same as R100		
R114	Same as R105		
R115	Same as R23		
R116	Same as R97		
R117	Same as R48		
R118	Same as R104		
R119	Same as R105		
R120	Same as R25		
R121	Same as R25		
R122	Same as R23		
R123	Same as R2		
R124	RESISTOR, VARIABLE, COMPOSITION: 1 megohm, 20%, 1W, linear taper, with spst switch "Pull to Close"	16925-570	1.22
R125	RESISTOR, FIXED, COMPOSITION: 150 ohms, 10%, 1/2W	18411-152	.46
R126	Same as R5		
R127	Same as R27		
R128	Same as R24		
R129	RESISTOR, FIXED, COMPOSITION: 390K ohms, 10%, 1/2W	18414-392	.46
R130	Same as R27		
R131	Same as R5		
R132	Same as R29		
R133	Same as R2		

REF. DESIG.	NAME AND DESCRIPTION	HICKOK PART NO.	PRICE EACH
R134	Same as R18		
R135	Same as R104		
R136	Same as R48		
R137	Same as R95		
R138	Same as R24		
R139	Same as R2		
R140	Same as R35		
R141	Same as R18		
R142	Same as R2		
R143	RESISTOR, FIXED, COMPOSITION: 2.2K ohms, 10%, 1/2W	18412-222	.46
R144	Same as R18		
R145	Same as R59		
R146	RESISTOR, FIXED, COMPOSITION: 3.3K ohms, 10%, 1/2W	18412-332	.46
R147	Same as R28		
S1	RELAY: reed, miniature size	18400-36	8.79
S2	Part of R124		
S3	SWITCH: rotary, range	19912-603	3.78
V1	CELL: photo, selected	3170-11	4.22
V2	Same as V1		
V3	Same as V1		
V4	Same as V1		
V5	LAMP: NE2U, aged and selected	12270-74	.48
V6	Same as V5		
	BOOKLET: instructions	2490-559	
	KNOB: small, black (display and picofarad cancel)	11505-171	1.55
	KNOB: black (range)	11505-172	1.55

NOTE: A minimum billing charge of $3.50 will be assessed for any parts order.
Prices are subject to change without notice.


ALT DRAWING NUMBER
C 900-204W
PICOFARAD CANCEL
CAPACITOR
PICO FARADS
NANO FARADS
MICRO FARADS
MILLI FARADS
RANGE S3
DISPLAY
PULL INF
S1-COIL
PIN 3
PIN 4
PIN 2
PIN 11
PIN 14
PIN 13
PIN 6
PIN 9
PIN 1
UNLESS OTHERWISE SPECIFIED, ALL RESISTORS ARE 10%, 1/2 WATT, VALUES IN OHMS. K=1,000 OHMS M=1,000,000 OHMS
CAPACITANCES ARE IN MICROFARADS PF=PICOFARADS
+NO CONNECTION
+CONNECTION
RX=CALIBRATION RESISTOR-EXACT VALUE DETERMINED IN PRODUCTION.
CX=CALIBRATION CAPACITOR-EXACT VALUE DETERMINED IN PRODUCTION.
+FRONT PANEL MARKINGS
RU=CALIBRATION RESISTOR-EXACT VALUE DETERMINED BY UNIJUNCTION VENDOR
SYMBOLS
LAST USED
NOT USED
C49
CR20
S3
S2
V6
SCHEMATIC WIRING DIAG.-MODEL DP-200
CAPACITY PLUG-IN